Pb(II) and Hg(II) binding to de novo designed proteins studied by 204mPb- and 199mHg-perturbed angular correlation of ¿-rays (PAC) spectroscopy

clues to heavy metal toxicity

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http://www.cern.ch/isolde

Introduction

ISOLDE, like the rest of CERN, is aimed at outside users, not internal ones. One consequence of this is that essentially all permanent personel involved in ISOLDE are in the technical group or in support groups. There are no physicists permanently at ISOLDE, and in the late summer it will be my turn to be replaced as physics groupleader. It will be a pleasure to hand over to Yorick Blumenfeld, who many will know from his present position as EURISOL coordinator. It is a particular pleasure to hand over a steadily growing collaboration: Norway joined last year and we were able to welcome Romania at the beginning of 2008. The increase in interest testifies to the health of our facility.

Apart from the extension of the REX beamline and the installation of the ISCOOL RFQ cooler and buncher, last year also gave many interesting physics results from ISOLDE. A selection of them are described later in this newsletter and more were discussed at the workshop in December (http://indico.cern.ch/conferenceDisplay.py?confId=20250). Results from ISOLDE will of course also show up at many of the conferences and meetings to be held later this year. I would like to single out one of these meetings, the EURORIB'08 conference (http://eurorib08.ganil.fr) to be held in Giens in France June 8-13, that aims at gathering together the European Radioactive Ion Beam community working towards the next generation facilities HIE-ISOLDE, SPIRAL2, NUSTAR (at FAIR), SPES and ultimately EURISOL.

It does not seem too well appreciated outside the ISOLDE community, but the HIE-ISOLDE project is in a very concrete sense already well on the way, with ISCOOL being installed and having its first commissioning run last year and with the major part of the RILIS upgrade taking place this year - see also the separate article in this issue. The physics report is now printed and in the postal mail to many of you (it is of course available as well at the website http://hie-isolde.web.cern.ch/HIE-ISOLDE/ - on this site you may also download the HIE-ISOLDE logo as shown in the figure below; please ask the ISOLDE secretariat for extra copies, should you need any). The funding for the project is increasing steadily and work has already started on the design of the energy upgrade of REX-ISOLDE.

The new HIE-ISOLDE logo

Finally, I should mention that ISOLDE – along with many of you – is taking part in the application for a continuation of the EU I3 project EURONS (through which our transnational access programme is funded). The project, handed in at the end of February, is called ENSAR and will be evaluated during the next few months.

Karsten Riisager

Changes in procedures for Users:

Several procedures for the registration of CERN Users have changed. In addition, new safety rules have been introduced including new safety courses to obtain a personal dosimeter and to obtain access to the ISOLDE hall. The main changes are described in the following sections.

Registration of ISOLDE teams

In order to facilitate the administration of the ISOLDE experiment teams, a new structure for the ISOLDE Collaboration was initiated last year. As described in the last newsletter, teams at ISOLDE will have to register only once (under ISOLDE Collaboration rather than under any specific IS number) and an official team leader or one of the two possible deputies will be able to sign when new users are registered for an ISOLDE experiment.

Many teams have already signed and submitted the new team registration form. However, the signed form is still missing from several teams. Note that new users cannot be registered unless the signed form has been given to the User's Office. The form is available on the web (http://ph-dep.web.cern.ch/ph-dep/UsersOffice/TLFormE.pdf). Please submit the form as soon as possible and contact the ISOLDE Secretariat if you have further questions.

Karsten Riisager

CERN Contract renewal

A new system has been introduced which will enable users to renew their CERN User contracts via EDH. If you have an EDH account and if you are a team leader or deputy then you could be asked to sign an EDH document for a member of your team. If you do not have an EDH account, a Team member can still fill in the document using EDH and then print it for you to sign.

This will be an additional way of renewing CERN User contracts, the previous way of renewal by completing the Check List form will continue for the time being.

Note that using EDH gives Users who are less than 50% at CERN (and therefore not holding Host States documents) the possibility to renew without coming to the Users' Office, providing that all supporting documents are attached with the EDH document (if not, they will need to be taken to the Users' Office).

CERN Users' Office

Obligatory radiation protection course

A new radiation protection course is becoming obligatory as of April 1st 2008 for CERN personnel, including Users, who are exposed to ionizing radiation in the exercise of their work, i.e. all persons having a personal dosimeter during the whole year. Participation in the course is validated by a test. Successful participation in the course, which lasts for half a day, is an obligatory prerequisite to receive or exchange a personal dosimeter.

Registration by EDH for the course is obligatory at the link (course in English): https://edh.cern.ch/Document/TRN/new?course=077V10. For further information please consult the CERN Bulletin http://cdsweb.cern.ch/record/1081136.

For all complementary questions on the radiation protection course please contact Mrs. Isabelle Cusato, phone 73811, Safety.Training@cern.ch, for questions concerning your personal dosimeter please contact the Dosimetry Service, phone 72155, dosimetry.service@cern.ch.

Please note that dosimeters without biometric information are issued for ISOLDE. Therefore, you do not need to do an iris scan when picking up your new dosimeter. An iris scan is only required for access to the LHC.

Dosimetry Service

Change in management of medical certificates at CERN

The Medical Service and the Dosimetry Service have set up a new procedure for registering the medical fitness certificates in order to facilitate the delivery of the CERN personal dosimeter. This procedure was adopted from November 1, 2007.

1. The update of the medical certificate in the data base will be made at the same time as the first delivery of the dosimeter and at every periodic exchange of the CERN dosimeter (usually once per year), in the Dosimetry service in building 55/1-001.
2. The dosimeter is given to the person or his/her representative against the presentation of a valid medical certificate or against the information of the valid medical certificate found in the dosimetry data base.

The medical certificate must be legible, complete and valid. Obligatory information that must be found on the medical certificate: complete identification of the person (with the CERN ID in the event of renewal), date of examination and period of validity. The doctor must pass the certificate directly to the patient in question or her/his representative. Transmission of certificates directly to the Dosimetry Service by fax, by email or mail will not be accepted. The medical certificate must be brought in person to the Dosimetry Service. Any difficulty in the reading of the certificate will lead to its treatment by the Medical service, which will then inform the Dosimetry service of the conclusion. The certificate should clearly state that the person may be admitted to radiation areas for work which can comprise a professional exposure to the ionizing radiation.

Templates of the medical certificates can be found on the Users' Office web pages (http://ph-dep.web.cern.ch/ph-dep/UsersOffice/UsersContractsInfo/UserContractsRegistration.htm). Use of these templates will assure the priority treatment of the certificate.

We would also like to remind you that the Dosimetry Service can give out a short term dosimeter once per calendar year which is valid for two consecutive months without a medical certificate.

Dosimetry Service

Safety at ISOLDE

At the end of 2006, the Director-General decided on a new approach for the implementation of safety at CERN. According to these safety rules, a new safety structure has been implemented at ISOLDE as well. For each of the approved ISOLDE experiments (ISXXX) a so-called GLIMOS (Group Leader In Matters Of Safety) has to be defined, who ensures that the experimental setups comply with the safety rules.

Usually, several IS experiments use the same permanent experimental setups like COLLAPS or ISOLTRAP. For practical reasons it has been decided to nominate a GLIMOS or an Installation Supervisor for these larger experimental setups at ISOLDE. For all other experiments either the ISOLDE Physics Coordinator or the Solid State

Physics Coordinator act as GLIMOS unless another person has been nominated. A list of the GLIMOS can be found in the CERN Greybook and on the ISOLDE web page.

The new CERN safety rules also have an impact on the access to the ISOLDE hall. In addition to the new RP course (part I and II) to get a dosimeter (see text above), another course will be offered (starting in Summer 2008) to obtain access to the ISOLDE hall. It is planned to have a web-based course which should be done after having passed the basic safety course and the RP course (part I+II). You will need an EDH account to enter the course.

Note that the Safety Commission has designed a leaflet for new CERN users. It will give an overview of the basic safety issues and contact numbers as well as web links. The leaflet will be available soon.

In general, there are several safety courses offered at CERN which cover the different safety aspects such as cryogenics, electricity, lasers, etc. Only a few courses like the one for radio protection are mandatory. It is recommended that you take part in these courses if your experiment makes use of cryogenic liquids, lasers, etc. More information can be found on the Safety Commission web page or contact the ISOLDE Physics Coordinator or the GLIMOS of your experiment.

Alexander Herlert

End of paper registration forms for new computer users.

It is now possible for new users to sign the Computer Centre User Registration Form electronically. As before, new users will still need to go to their Computing Group administrator[1] who will make the electronic request for account creation using CRA and give the new user their initial password. The difference is that the requested accounts will be created and usable almost immediately. Users will then have 3 days within which they must go to the web page http://cern.ch/cernaccount and click on 'New User'. They will be required to follow a short computer security awareness training course, read the CERN Computing Rules, and then confirm that they accept the rules. If this is not completed within 3 days all their computer accounts will be blocked and they will have to contact the Helpdesk to unblock their accounts and get a second chance to complete the registration.

In addition, we also encourage all existing users to follow the awareness training: http://sir.cern.ch/sir/f?p=106:26
The training is part of the Safety Information Registration system (SIR) and completion of the training is recorded in the persons safety training record of the HR (Personnel) database.

IT User Registration

Changes in the Shipping procedure at CERN

There will be a number of changes in the procedure for the shipping of material from CERN/ISOLDE over the course of 2008. Although most of these should be essentially transparent to users, there are significant changes being made to the database of shipping licenses. This is now located at http://cern.ch/radship and is

[1] ISOLDE Secretariat or ISOLDE Physics Coordinator

currently in a state of migration. During this period – expected to last for at least a number of months – users who are importing/exporting material should notify the local shipping contact at ISOLDE, Karl Johnston (karl.johnston@cern.ch), who will then alert the appropriate people in the shipping and logistics divisions.

Once the database is updated, users should ensure that their data are correctly registered in the database so that smooth processing of shipping requests can be guaranteed. It will be the users' responsibility to make sure that their respective institute's data are correct; updates about pending expiration dates will be sent every two years. The new database will also allow users to add and edit information themselves.

In addition to the ISOLDE shipping contact given above, there are three relevant emails should there be further questions. For all radiological questions regarding radioactive shipments: service-rp-shipping@cern.ch; for all general questions regarding the logistics of shipping e.g. choice of transport: logistics-service@cern.ch; and for all questions which are related to gamma spectrometry: service-spectrometry@cern.ch.

Karl Johnston

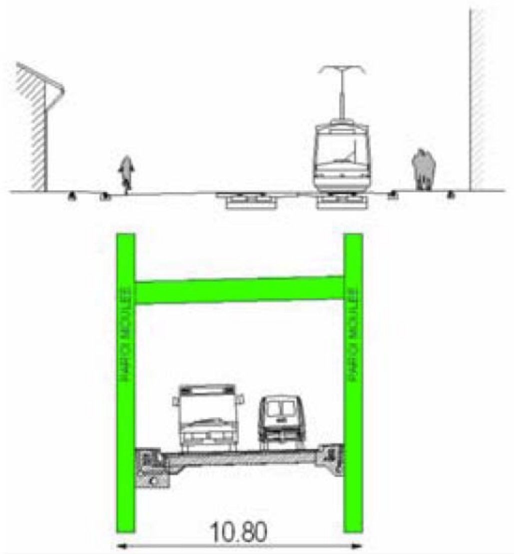
Change in (public) transport to CERN

In the framework of the work on the new Cornavin-Meyrin-CERN tramline, an underpass (565 m length) is to be cut into the hill of Meyrin village where the Route de Meyrin meets the Avenue de Vaudagne and the Avenue Virginio-Malnati. As a result, the Route de Meyrin has been closed to through traffic for a period of two years from Monday 11 February 2008. For further details see: http://cdsweb.cern.ch/journal/article?issue=08/2008&name=CERNBulletin&category=General%20Information&number=1&ln=en

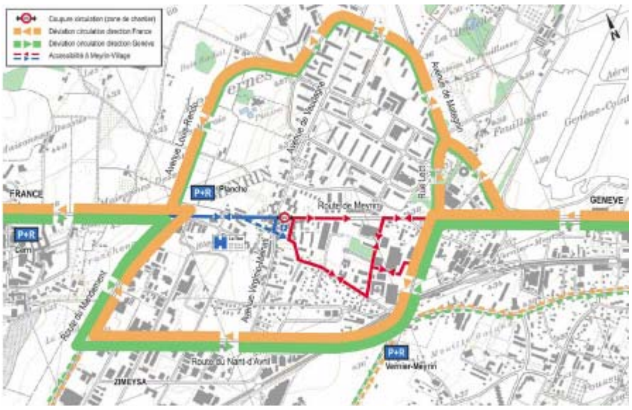
The following traffic diversions will be in operation:

- Traffic travelling in the Geneva-France direction will be diverted along the Avenue de Mategnin and the Avenue Louis-Rendu or the Route du Nant-d'Avril and the Route du Mandement,
- Traffic travelling in the France-Geneva direction will be diverted along the Route du Mandement and the Route du Nant-d'Avril.

There will also be special diversion routes in the centre of Meyrin reserved for access to shops, houses and flats and the La Tour hospital.



Planned tunnel for cars and busses through Route de Meyrin.



Detour of traffic around construction site in Meyrin.

Also the public transport lines in Geneva were changed considerably last December. If you now want to reach CERN by public transport, please note that bus 9 will no longer come here. From the airport you can take bus 28 to Hopital-la-Tour (end station) and change there to bus 56 or bus Y. Alternatively, you may take bus 10 until Bouchet, change there to tram 14 or 16 going to Avanchet and change again to bus 56 or bus Y. From the train station, take tram 14 or 16 to Avanchet and change to bus 56 or bus Y. By the end of this year the trams will be extended to Meyrin and in two years from now one of the trams will be extended all the way to CERN.

Full details of the project (in French) can be consulted on the following website: http://www.geneve.ch/dcti/presse/2008-02-05_conf.pdf

Lectures in 2007/2008

The next generation of physicists to work at ISOLDE need not only to become acquainted with the experimental set-ups and procedures here, they also need to become familiar with the theoretical models and tools used for understanding our physics. The major event in this direction in 2007 was the nuclear theory school in May organized by Joakim Cederkall and others. As usual all material from the school can be found on the web via www.cern.ch/isolde-nt2007.

We had during September several lectures on the IBA given by Rick Casten. They can also be seen via http://indico.cern.ch/conferenceDisplay.py?confId=21569. There are plans to have Prof. Casten visit ISOLDE again this year from mid July to mid August. Another recurrent and welcome visitor for several years is Kris Heyde. Very recently he gave a set of lectures based on the shell model, again available via http://indico.cern.ch/conferenceDisplay.py?confId=29525.

Karsten Riisager

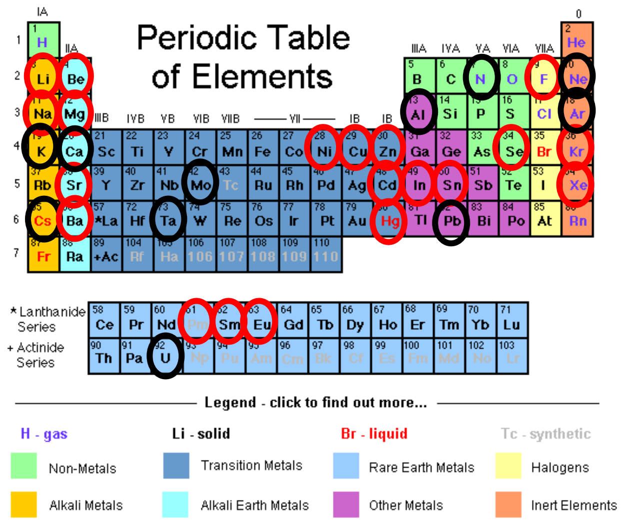
German PhD program

A new German Doctoral Student Program at CERN (Wolfgang-Gentner-Stipendien), funded by the Bundesministerium für Bildung und Forschung (BMBF), was set-up in October 2007. Approximately 20 students per year will be supported for a period of up to 3 years. The German Doctoral Student Program is fully integrated into the CERN Doctoral Student Program. Special topics for PhD theses that are related to ISOLDE can be found on the ISOLDE web page (http://isolde.web.cern.ch/ISOLDE/opportunities/germanphd.htm). Please note that the next deadline for applications is on August 7, 2008. For further information contact Mats Lindroos or Alexander Herlert.

Alexander Herlert

REX-ISOLDE

The REX-ISOLDE post accelerator has been operational for more than 6 years and thereby reached a mature state. Radioactive beams of 53 isotopes from twenty different elements, ranging from Li to U, have been post-accelerated so far [1,2].



Radioactive elements accelerated (red) and a selection of stable elements charge bred (black) in REX.

During the 2007 campaign 3 new elements and 7 new isotopes (^{96}Sr, ^{140,142,148}Ba, ^{184,186,188}Hg) were delivered for physics, coming either as atomic ions or molecular ions from ISOLDE. Apart from the 7 experimental runs scheduled a dedicated test run with SrF, F being the carrier atom, was performed to demonstrate the production and breeding of a clean Sr beam using the molecular sideband technique. Later during the year molecularly extracted beams of Sr and Ba were accelerated for physics. In general, the molecular sideband technique has proved its capability to supply clean beams and is now considered as one of the standard operation modes at REX, but for the ^{148}Ba^{19}F^{+} case it was found that the isobaric suppression was not sufficient with a strong unexpected contamination of mainly ^{148}Nd^{19}F^{+}. It demonstrates the requirement of a careful beam characterization in advance with protons on target and beams analyzed with the ISOLDE tape station, as an ad hoc prediction is not unfailing.

In 2007 ^{17}F could finally be delivered to the experiment, this time extracted in an atomic form from ISOLDE. With the use of carbon stripper foils in the end of the REX linac ^{17}F^{5+} was stripped to ^{17}F^{9+} and selected with the bending magnet, while the contaminant ^{17}O ended up as 8+ and was in that way eliminated.

Internal discharges inside the REXTRAP rendered it nonfunctional for some time in the beginning of the year. In spite of this, the experimental runs could be carried out by operating the EBIS in continuous injection mode. That meant leaving the trap switched off and taking the semi-continuous beam directly from ISOLDE into the EBIS. Although the efficiency is reduced, it opens up future possibilities with the newly installed and operational RFQ cooler. In the near future we intend to test injection of RFQ-cooled CW beams directly into the EBIS, and with the REXTRAP being bypassed, we could possibly augment the overall beam throughput. Another expected effect of the RFQ-cooler is its equalization of the varying extraction energy for different elements (e.g. noble gases and metals) from the ISOLDE plasma sources, which should facilitate the injection into the REXTRAP when it is operated in normal mode.

So-called closed shell charge breeding has been evaluated. The idea is to make use of the atomic shell gaps and by adjusting the energy of the ionizing electron beam below the ionization potential one can narrow the charge state distribution and force a larger fraction of the charge bred ions into a single charge state, thereby increasing the efficiency (theoretically up to 100%). The method has inherent limitations: suitable shell gaps around 2-5 keV has to be found and processes (radiative recombination, evaporative ion losses) competing with the ionization may curb the efficiency. Unfortunately the experimental results showed that excessively long breeding times are required and that the charge breeding efficiency is lower than for normal breeding (for reasonable breeding times). Thus, it was concluded that the method is not an alternative for REX.

The REX-ISOLDE post accelerator has now attained the title of "heavyweight champion". The charge breeder was originally designed for isotopes with A<50, however, recent tests showed that $^{238}U^{52+}$ can be charge-bred with a 4.3% efficiency for a 498 ms breeding time. In 2007 REX has seriously entered the arena of heavy ion beams by accelerating light Hg isotopes to full linac energy (2.8 MeV/u) for physics experiments. The success was alleviated by the fact that neutron deficient isotopes were to be accelerated, but already now a number of even more challenging proposals with still heavier elements are in the pipeline. Apart from the difficulties of attaining a sufficiently low A/q-value for the accelerator (<4.5), the decay chains of these heavy elements often contain long-lived and contaminating daughter nuclei that must be considered carefully.

A number of technical developments were carried out at REX last year. Most noticeable was the completion of the Minimove, that is the extension of the beam transport line and move of the experimental stations. The move enabled the installation of extra X-ray shielding, although the background levels are still high at the Miniball setup and further shielding actions are planned (installation of lead collimators and mobile screens on the beamline after the 9-gap cavity). The source of background has been identified as being mainly due to X-rays on axis and Compton scattering in the bender/beamline. Also worth noticing was the conclusive consolidation of the RF-amplifier for the 9-gap cavity, which can now deliver the design power and finally accelerate beams to full energy with high repetition rates (>50 Hz). Several improvements are foreseen also for 2008.

Nevertheless, to meet the requests of a wider experimental programme and making full use of the vast range of isotopes available at ISOLDE, higher beam energies are required. Thus, REX, with the support of external and internal CERN groups, launched an ambitious programme in the end of 2007 aiming to produce prototype cavities for a superconducting linac boosting the beam energy to 5 MeV/u, and at a later stage up to 10 MeV/u [3].

[1] http://isolde.web.cern.ch/ISOLDE/REX-ISOLDE/index.html
[2] D. Voulot et al., 'Radioactive beams at REX-ISOLDE: present status and latest developments', submitted to Nucl. intr. and Meth. B (EMIS2007 proceedings)
[3] M. Matteo et al., 'A superconducting linac for the energy upgrade of REX-ISOLDE at CERN', submitted to Nucl. Instr. and Meth. B (EMIS2007 proceedings)

Fredrik Wenander

News from ISOLDE laser ion source: LARIS laboratory and RILIS upgrade

At ISOLDE, following the off-line development of the Resonance Ionization Laser Ion Source (RILIS), the installation of a permanent laser ion source at the PS-BOOSTER ISOLDE was proposed in 1993. The present laser setup is based on copper vapor lasers (CVLs) running at pulse repetition rate of 11 kHz. The CVL system, consisting of a laser oscillator and two parallel amplifiers, is built using commercially produced, sealed-off, discharge-heated CVL tubes. Dye lasers are transversely pumped by CVLs to produce wavelength-tunable beams in the range of 530-850 nm. The tuning range of the dye lasers can be extended to the ultraviolet region by doubling and tripling the light frequencies. In total, isotopes of 27 different elements have been selectively laser-ionized and separated at ISOLDE. The list of RILIS ion beams and details of applied ionization schemes are presented at http://isolde-project-rilis.web.cern.ch/isolde-project-rilis/. This page is linked to the ISOLDE web page.

Presently, the annual usage of RILIS has exceeded 2000 hours and for about half of the available proton beam time, ISOLDE is running with RILIS.

The experimental work to search for ionization schemes has been carried out using the existing RILIS setup at the ISOLDE on-line facility (except Yb, Tm, Sn and Ni, for which ionization schemes have been found at the Institute of Spectroscopy and at Mainz University). Since the time allocated for such studies have usually been limited to a few weeks of the annual winter accelerator shutdown, the results obtained are not always fully satisfactory in terms of the completeness of the spectroscopic research and the ionization efficiency achieved. In particular, a non-resonant transition to the ionization continuum is used as the last step of atomic excitation for most schemes. Using schemes with transitions to autoionizing states could in many cases improve the ionization efficiency but the search for such transitions requires roughly an order of magnitude more time than it has been possible to allocate.

Consequently, a project to set up an auxiliary laboratory for LAser Resonance Ionization Spectroscopy (LARIS) has been launched. At present, the laboratory is equipped with two broadly tunable optical parametric oscillators and a dye laser, all pumped by low repetition rate (10 Hz) Nd:YAG lasers. The interaction of laser beams with the atoms under investigation will take place in a vacuum. The simplest approach is to use a vacuum chamber with an atomic beam source and an ion detector (secondary electron multiplier). The commonly used resonance ionization spectroscopy techniques of laser ablation and time-of-flight mass spectrometry are implemented also. In particular, a reflectron-type time-of-flight mass spectrometer has been provided and set at the LARIS laboratory by KTH Stockholm.

The conditions of laser-atom interactions at LARIS installation are not identical to those at RILIS. Still, the choice of optimal ionization schemes can be done on the basis of relative measurements of ionization efficiency. The absolute values of ionization efficiencies for selected schemes are to be determined at RILIS setup.

The RILIS laser system is old and reliant upon components that are no longer readily available. Most of the CVL and dye laser system was manufactured 15 years ago. The maintenance and operation of the RILIS lasers requires substantial efforts. The stable performance of the RILIS setup is of great importance for the ISOLDE facility, therefore all possibilities for upgrading the RILIS lasers had to be considered in order to define an optimal solution. In particular, the following scenarios were discussed:

- Replacement of the old CVL by a new commercial CVL.
- Replacement of the CVL by solid-state lasers.
- Creating a new fully solid-state laser system.

Finally, it was concluded that it would be feasible and favorable for the improvement of RILIS functionality to implement industrial solid state lasers (SSL) as a replacement for the copper vapor lasers. The market survey revealed several companies capable of supplying diode-pumped SSLs with the required parameters and tender has been won by the German company EdgeWave GmbH. The SSL system consisting of a slab-type Nd:YAG oscillator and power amplifier running at the pulse repetition rate of 10 kHz will provide three output beams: two green beams (532 nm) with total power >80 W and one 20 W ultraviolet beam (355 nm). With this laser system the wavelength range of RILIS will cover the whole visible spectrum, ultraviolet down to 210 nm and near infrared. The installation of new solid state lasers is planned for the shutdown 2007-2008. The old CVL system will be still on place and available for backup until the stability and advantages of SSL system will be proven.

The funding for RILIS upgrade and LARIS project has been generously provided by the Knut and Alice Wallenberg Foundation (Sweden), grant KAW 2005.0121. This work was performed also with support from the European Union Sixth Framework through RII3-EURONS contract no. 506065.

Valentin Fedosseev

ISCOOL on-line commissioning

As one step towards HIE-ISOLDE the ISOLDE ion cooler and buncher - the so-called ISCOOL - was successfully commissioned in the last month of the on-line period of 2007. For some aspects its performances even exceeded expectations. Its future use at ISOLDE presents a great potential for many experiments.

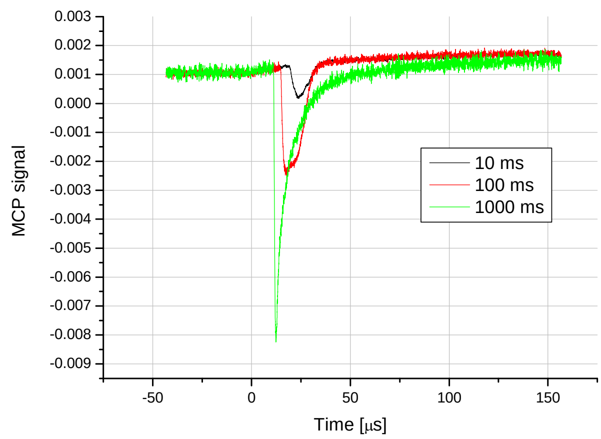
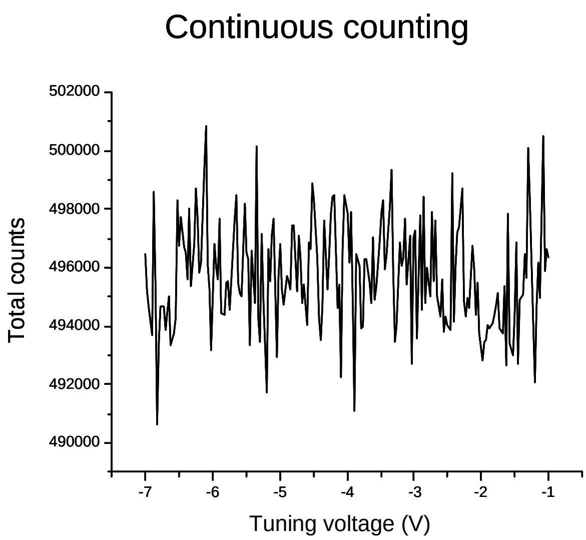


Fig. 1: Time of flight profile as observed with the MCP for $^{39}K^{+}$ ions and for different collection times. See text.

Cold and bunched beams for Physics

First developed for Penning trap mass spectrometry, RF coolers have shown since their origin excellent effectiveness for enhancing the sensitivity of experiments manipulating rare radioactive ion beams. The bunching and cooling capabilities of one of the very first prototypes was successfully demonstrated at ISOLTRAP, where the cooler was shown to greatly enhance the capture of ions by Penning traps. Isotopes previously beyond reach became accessible: with less than 100 ions per second from ISOLDE, the mass of ^{32}Ar was measured with $6x10^{-8}$ accuracy in 2002. Since then, similar devices were developed at many other locations. Among others at MISTRAL, where used in simple transmission mode the reduction of transverse emittance aims at improving the resolution and the overall efficiency through the small acceptance spectrometer.



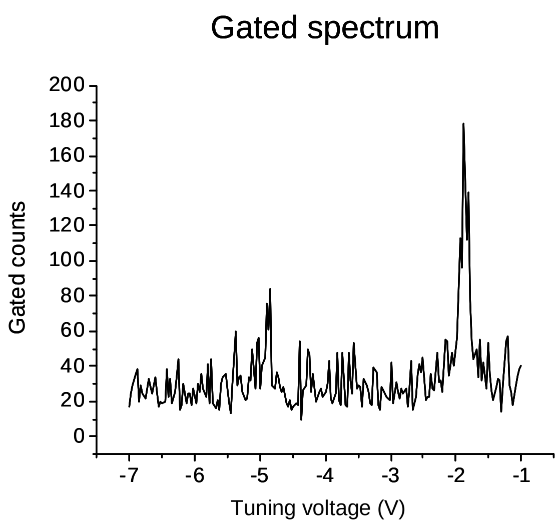


Fig. 2: Example of reduction of background on the fluorescence spectrum of 46K at Collaps by gating on the time structure of the cold bunches.

The possibility of manipulating the longitudinal emittance i.e. the bunching mode is useful for experiments requiring a time reference, for e.g. half-life measurements, or for reducing noise in e.g. laser spectroscopy experiments. ISCOOL will be a key part of future experiments at COLLAPS and for the new collinear resonant ionization spectroscopy project (CRIS). It will extend the capabilities of low energy beam preparation at REX-ISOLDE by optimizing the capture and possible mass selection in REXTRAP. In general it will permit a much better control of the beam transport in the ISOLDE experimental areas, thus reducing significantly the setting-up time for all experiments including e.g. ISOLTRAP and LA1, LA2 experiments. The delivery of cold and bunched beams to ISOLDE beam lines in a more systematic way than it was done up to now will present many opportunities for physics experiments, provided that the RF cooler ISCOOL has no major limitations. This is what was verified in the first on-line tests briefly summarized here.

Results from the on-line tests

The ISCOOL performances were first determined using stable and radioactive alkali beams from a Ta target and W ionizer. Record transmissions were obtained for ^{23}Na (50%), ^{39}K and ^{85}Rb (80%) indicating an optimized efficiency of about 80% for masses A>40 and slowly decreasing below. A loss map was recorded by injecting a ^{44}K beam for several half-lifes and then measuring the collected activity in the RF cooler surroundings. An almost symmetric profile of losses mainly situated at the injection and extraction regions could be observed. The bunching mode was tested for all accessible stable alkali ions. A record space charge capacity of about 10^8 particles per bunch was measured on

Faraday Cups and on a Micro-Channel Plate (MCP), which is at least two orders of magnitude higher than ordinary coolers. Transmission and bunched mode were in addition tested with ^{26}Na isotopes using the tape station. These results are currently under analysis. Figure 1 presents the time of flight profile of bunches of ^{39}K as measured by the MCP for different collection times. For 1s, the trap is completely filled by ions. For optimized trapping conditions and far away from the space charge limit, the bunch width was measured by the COLLAPS experiment where a time focus of 7μs was observed using the $S_{1/2}$-$P_{3/2}$ transition of ^{44}K. Using the same setup a reduction in background by more than four orders of magnitude in the fluorescence spectrum of ^{46}K (see Fig. 2) could be achieved by using 300ms cycles from ISCOOL and gating the photomultiplier signal on the ion bunches (in this case 12μs), showing the excellent potential of such a combination for future experiments. Finally, a large beam of ^{40}Ar from a standard hot plasma source could be transmitted with more than 50% efficiency when accepting the full beam through HRS and with 80% efficiency when inserting the slits.

P. Delahaye, K. Flanagan and H. Frånberg

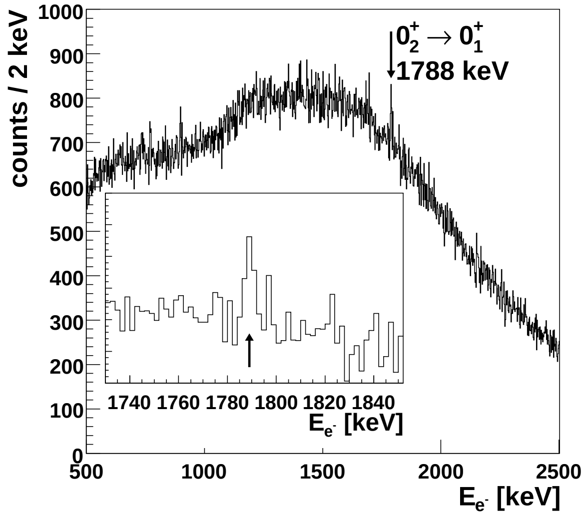
Experiment reports:

IS414 - First identification of the E0 transition between shape-coexisting 0^+ states in ^{30}Mg

More than 30 years after the discovery of the "Island of Inversion" at ISOLDE [1] this mass region around the N=20 shell closure in Na, Mg and Ne isotopes is still in the focus of current nuclear structure studies. This region is represented by the occurrence of strongly deformed ground states, resulting from the promotion of a pair of neutrons across the N=20 shell gap, thus leading to the intrusion of deformed low energy (2p2h) states below the spherical (0p0h) states compared to nuclei closer to β stability.

A shape coexistence of spherical and deformed 0^+ states is predicted to exist within and at the borderline of this 'Island of Inversion' in neutron-rich Mg isotopes around N=20, however, so far spectroscopic properties are available only for the 0^+ ground states. While the closed-shell nucleus ^{32}Mg exhibits a superdeformed ground state as indicated by the large value of $B(E2;0_{gs}^+ \rightarrow 2_1^+)=454(78)e^2fm^4$ measured via Coulomb excitation [2], the ground state of ^{30}Mg is expected to be much less deformed, despite of its rather large B(E2) value (241(31) e^2fm^4) measured at REX-ISOLDE with MINIBALL [3], whereas the (deformed) excited 0_2^+ state so far escaped observation.

However, within the fast-timing studies of IS414 by H. Mach *et al.* [4] the 1789 keV state in ^{30}Mg emerged as a strong candidate for the 0_2^+ state due to its long lifetime of 3.9(4) ns and the absence of a direct ground state γ decay [4].



Background subtracted electron spectrum measured in coincidence with β decay electrons. The inset shows the 0_2^+ -> 0_1^+ E0 transition in ^{30}Mg.

This triggered our conversion electron spectroscopy campaign that we conducted within IS414 in the last 3 years to search for the E0 transition between the shape-coexisting 0^+ states in ^{30}Mg after β decay from ^{30}Na. We used a Mini-Orange spectrometer, i.e. a magnetic filter and transport system consisting of 8 wedge-shaped permanent magnets creating a toroidal magnetic field. Electrons from the target are focussed onto a (cooled) Si(Li) detector, direct sight of the detector onto the target is blocked by a central Pb absorber (thus preventing γ ray detection). Electrons from the E0 decay are measured in coincidence with β decay electrons detected in a plastic scintillator, while a germanium γ ray detector serves as monitor for the beam composition.

The experimental challenge is given by the rather high Q value (17.3 MeV) of the ^{30}Na β decay, giving rise to a large background from high-energy γ rays and subsequently Compton-scattered electrons.

We achieved optimized sensitivity to weak E0 transitions by e.g. consequently reducing the amount of high-Z materials in the target chamber, preventing X-ray production near the target, coating the interior of the target chamber with 15 mm Teflon to absorb Compton-scattered electrons and by reducing the thickness of the β plastic scintillator to 0.2 mm in order to reduce its sensitivity of γ rays.

In our August 2007 experiment we finally succeeded to identify the long-searched $0_2^+ \rightarrow 0_1^+$ E0 transition at exactly the expected position, confirming the assignment of the 1789 keV state (see figure). From the intensity of the transition and the known lifetime of the state the electric monopole strength [5] can be determined as $\rho^2(E0)=5.7(12)\times10^{-3}$. This small value indicates a rather weak mixing between the two potential minima, which was not expected. Our results also allow to extract the mixing amplitude between the two 0^+ states as a=0.15(2). A consistent description of the small monopole strength and the large B(E2) value presently is only possible within a phenomenological interpretation that assigns a rather large (effective) deformation of β=0.39 to the ground state in ^{30}Mg, while the superdeformed shape of the 0_2^+ state (β=0.57) still places this nucleus outside the Island of Inversion. Hopefully microscopic theories will soon be able to shed more light onto this intriguing region of shape coexistence.

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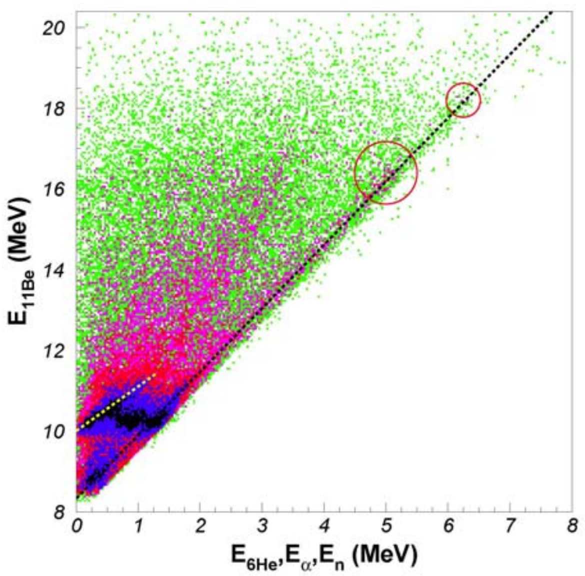
P.G. Thirolf, W. Schwerdtfeger, D. Habs et al.

IS417 - Delayed particle study of neutron rich lithium isotopes

The study of the beta-delayed charged particle emission from light nuclei presents a remarkable challenge to both experimental and theoretical nuclear physics. The role played by nuclear structure in the energy and momentum distribution of the emitted particles is not yet fully understood on the theoretical side, and obtaining definite experimental proof of decay mechanisms is notoriously difficult. Our collaboration has performed a successful set of experiments dedicated to light particle-emitting nuclei. The halo nucleus ^{11}Li decays through six different decay channels including the emission of charged particles, ^{10}Be+n, ^{9}Be+2n, 2α+3n, n+α+^{6}He, ^{8}Li+t and ^{9}Li+d [1]. Recent studies of gamma-neutron coincidences [2] and the doppler-broadening of gamma lines due to neutron emission [3] have shed a light on the ^{11}Be levels involved in the first two channels, and a successful description of this decay modes has been obtained in the AMD framework [4]. The last four channels, however, remain relatively unknown. The use of highly segmented detectors in a compact geometry allowed us to do a very efficient coincidence study and thus to determine the decay mechanism for beta-delayed alpha emission in ^{9}C, ^{9}B and ^{12}B/^{12}N [5-7]. These studies showed how the intermediate resonances play a role in the break-up mechanism.

The experiment IS417, reported here, is dedicated to the study of the ^{11}Li beta-delayed charged particle emission. The idea behind is to compare the Gamow-Teller strength distribution of the β-decay of ^{11}Li with that of its core, ^{9}Li. Strong similarity in the decay patterns will support the factorization of the wave function of the ^{11}Li

ground state in core and halo components [8]. The ^{9}Li β-decay has been studied from data obtained in calibration test done during previous experiments such as IS404, reported in the October 2003 ISOLDE newsletter. The first run was done in 2003 and evidence of sequential decay through He resonances was found, but the lack of statistics prevented us to reach a definitive conclusion. A new run was done in October 2007, where a new set-up even more compact that the one used in 2003 and, therefore, more optimized for coincidence measurements was used obtaining five times more coincidence events than those registered in 2003.



Excitation energy in ^{11}Be vs. energy of the emitted particles.

We concentrated in studying the charged particle coincidence events. This reduces the number of detectable channels to only 2α+3n and n+α+^{6}He, as the triton and deuteron branches are very hard to detect in coincidence because of the low recoil energy of the Li fragments. The n+α+^{6}He channel is ideally suited for our experimental study, as being a three body break-up we can reconstruct the neutron energy, and therefore, the ^{11}Be excitation energy, using energy and momentum conservation from the detected alpha and ^{6}He. This allows us to determine the break-up mechanism, as the energy of the first emitted particle in sequential decay is fixed by kinematics. In the n+α+^{6}He β-delayed break-up of ^{11}Be, the break-up can occur through intermediate steps involving ^{10}Be+n, ^{7}He+α or ^{6}He+^{5}He. If we plot the energy of the three emitted particles versus the excitation energy in ^{11}Be, as shown in the figure, the first emitted particle forms a line of slope and offset given by the kinematics of the first step of the break-up. Two distinct lines can be seen in the plot. The most intense one, marked with a yellow dashed line of 11/10 slope and 10 MeV offset, corresponds to the known neutron emission from a 10.6 MeV state in ^{11}Be into a 9.5 MeV state in ^{10}Be [9]. The fainter line, marked with a black dashed line of slope 11/7 and 8.33 MeV offset, corresponds to a new decay channel through the ground state of ^{7}He resonance. This diagonal line shows higher intensity at 18.2 MeV as expected and also around 16.5 MeV (highlighted by two red circles in the figure), indicating that more than one state of ^{11}Be in this energy region contributes to this channel.

As summary, the preliminary analysis of the data taken in 2007 confirms that the β-fed states in ^{11}Be beyond the charged particle threshold break up via the ground state of ^{7}He, as proposed from the analysis of the 2003 data. Moreover the analysis of the reconstructed ^{11}Be excitation energy indicates the feeding of a previously unknown state at 16.5 MeV.

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Miguel Madurga

IS418

The first excited 2^+ states in the even-even Sn isotopes have traditionally been seen as a good example of a series of states that is well described within the generalized seniority model. In short this model predicts that the properties of the states it is applied to can, to a large extent, be understood with the help of the number of broken pairs outside of a shell closure. In this model the number of such pairs is associated with a quantum number, the seniority,v, which takes on values 0,2,...etc depending on how many particles that form broken pairs. The generalized seniority model by Talmi is an extension of the early seniority model for a single j-shell put forward by Racha. Two main predictions can be brought over from the single-j scheme into the generalized model.

In our specific case the first predicition says that the excitation energy of the first excited 2^+ state remains constant. This is due to the fact one expects this state to be dominantly a v=2 state over the full sequence. The second prediction is that the transition probability from the 2^+ state to the ground state has a simple dependence on the filling of the major shell. In the somewhat simplified terms used here this dependence gives a parabolic relation between the reduced transition probabilities and the filling and peaks at midshell.
One can mention that large-scale shell model calculations show a seniority, v=2, overlap for the first excited 2^+ states, to be roughly 80-90%. This is of course an indication that the model is an approximation, although a rather good one. As a matter of fact the energy of the first excited 2^+ state in this sequence is known from ^{130}Sn to ^{102}Sn and lies somewhat above 1200 keV with a variation of ~100 keV. However, the transition rate from this state to the ground state has for many years been known only in the stable even-even Sn isotopes. If we focus on the neutron deficient isotopes, the reason for this state of affairs is ultimately related to the orbits that dominate the configurations, i.e. the $g_{7/2}$ and $d_{5/2}$ neutron orbits. Two particles in these orbits can couple to a maximum spin of 6 and thus results in a 6^+ state. However, the energy of this 6^+ state turns out to be rather close to the energy of the lower lying 4^+ state built on the same configuration but with a different spin coupling.

As a consequence this rather small energy difference leads to the 6^+ states becoming isomeric with half-lives in the ns range. Due to the lack of de-excitation paths bypassing the 6^+ states it becomes very difficult to measure the life time of the 4^+ and 2^+ states below this state. Fusion evaporation reactions, therefore, cannot be applied in this situation. The solution is instead to measure the transition rates using Coulomb excitation of radioactive ion beams of the isotopes of interest. One should note here that the lightest stable even Sn isotope is ^{112}Sn. Consequently the $g_{7/2}$ and $d_{5/2}$ orbits mentioned above are expected to start to play a dominating role in the first unstable neutron deficient isotope, i.e. $_{110}$Sn. Here it becomes interesting to note that a deviation in the expected parabolic trend of the transition probabilities has been observed in ^{114,112}Sn but that it has not been possible to investigate if this anomaly extends also into the lighter isotopes. An enhancement of the transition strength can be due to many factors. One can mention the E2 coupling between protons and neutrons occupying the $g_{9/2}$ orbit below the N=Z=50 gap and the corresponding $d_{5/2}$ orbits above the gap.

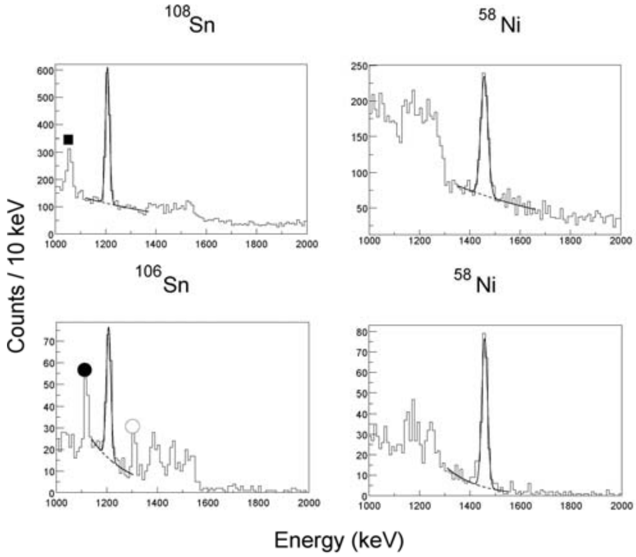


Fig. 1: Spectra as obtained with MINIBALL.

Similary one can argue that the binding of the protons below the gap will relate to the number of neutrons occupying the $g_{7/2}$ spin-orbit partner above the gap. In more general terms one could furthermore argue that changes in the mean field potential with a decreasing number of neutrons could influence the spin-orbit splitting or lead to proton-skin effects. All these theoretical arguments ultimately point to the issue of how particle correlations influence nuclear structure close to the N=Z line. In order to shed some light on this issue we have performed a series of experiments at REX-ISOLDE and MINIBALL beginning in 2004. In these experiments we measured the reduced transition probabilities mentioned above in ^{110,108,106}Sn using Coulomb excitation. As the experimental methods used in the measurements have been described in the past we just note that the result is that the trend of enhanced strengths measured in ^{114,112}Sn extends also into the lower mass isotopes.

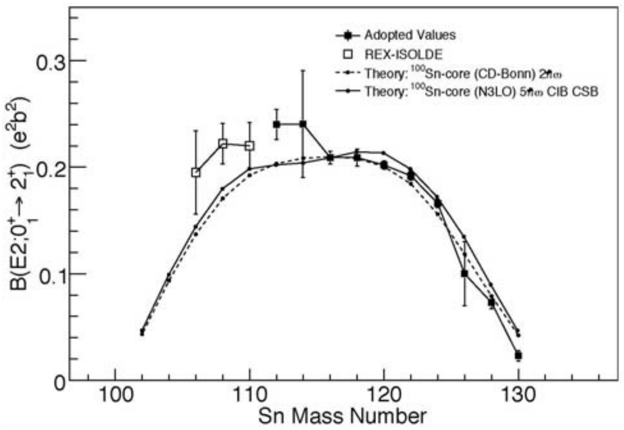


Fig. 2: Trends from experimental results for the reduced transition probabilities as compared to results from calculations.

The experimental spectra can be seen in Fig. 1. Parallel work, using intermediate energy Coulomb excitation, by part of our collaboration at GSI has given a similar result but with considerably less precision for ^{108}Sn.

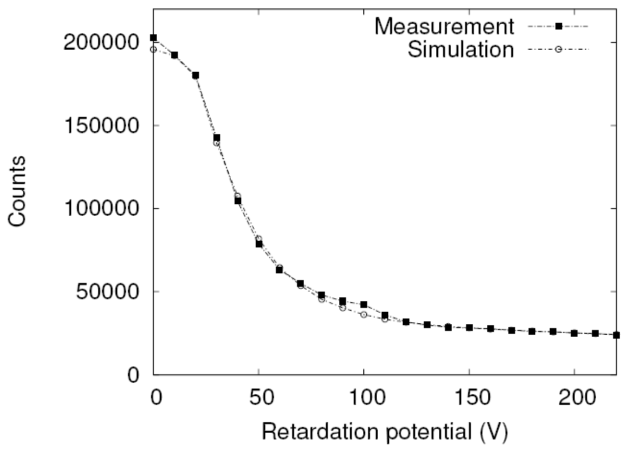
From the discussion above it is clear that calculations related to this effect need to take core excitations into account. This is, however, a challenging issue due to the large model space needed. Previous calculations have therefore introduced truncated spaces. One such calculation by F. Nowacki et al., using seniority truncation, shows an enhanced strength midshell but naturally produces a symmetric trend around A=116. The approach we are employing to calculations in this region, in collaboration with M. Hjorth-Jensen at Oslo university, relies on effective nucleon-nucleon interactions derived using G-matrix theory. Particularly interesting is a recent development using an interaction, N3LO, that has nucleons and pions as the only effective degrees of freedom. This interaction also breaks charge independence and charge symmetry. In Fig. 2 we indicate the trends from the experimental results for the reduced transition probabilities together with results from some calculations. One notes the symmetric trend for the calculation based on a CD-Bonn potential without charge symmetry and independence breaking compared to the more asymmetric trend of the N3LO calculation. At this stage one should note that an explicit expansion of the model space to include protons in the $g_{9/2}$ orbit below the gap requires parallelized calculations on a computational cluster. Work towards this end has recentlty started and is expected to be completed within one year. The experimental data has been submitted for publication.

Joakim Cederkall

IS433 - The WITCH flies

The WITCH experiment (Weak Interaction Trap for CHarged particles) [1] is set up foremost to determine the β–ν angular correlation in the β-decay of exotic nuclei from the shape of the energy spectrum of the recoil ions. This will permit to search for the presence of scalar/tensor components in the weak interaction, the amplitudes of which could be as large as about 10% of the vector interaction.

The main parts of WITCH are two Penning traps and a retardation spectrometer. Ion bunches delivered by REXTRAP are decelerated with a pulsed drift tube. They are trapped and buffer gas cooled in the first of two cylindrical Penning traps and transferred to the second one, the decay trap. Recoiling daughter ions from β-decays in the decay trap can leave this trap without any significant energy loss or scattering. They are guided by a 9-T magnetic field into the retardation spectrometer (placed in a 0.1-T magnetic field) where their energy is analysed. Those that make it over this barrier are counted with a position sensitive MCP detector.



Integral ^{124}Sn recoil ion energy spectrum obtained after the β- decay of $^{124}In^{1+}$ ions in the WITCH decay Penning trap.

In the past few years the set-up was completed and its performance improved. Main achievements were the shaping of the REXTRAP pulse so that it now fully fits in the WITCH pulsed drift tube, a new diagnostic system, the better understanding of the response of the MCP's to pulsed beams, the optimisation of the handling of the pulsed drift tube voltages, and a new and much improved version of the control system that was developed. All these have resulted in an overall increase of the beam transport efficiency in the vertical beam line, including the injection of the beam into the magnetic field, of up to two orders of magnitude. The total efficiency of the set-up (for β^+ decays) is now ~0.1 to 0.2%, which is about a factor ten below the ideal (maximal) value.

At the end of the 2006 running period a first energy spectrum of recoil ions from beta decays in WITCH was obtained as well (see figure) [2]. With this the proof of principle of the WITCH apparatus has been successfully demonstrated. In July 2007 the original set of Penning traps (for testing) were replaced by new ones that were also properly coated. With these, a mass resolution M/ΔM of about $2x10^5$ was readily obtained, allowing for the separation of isomers in a number of cases.

At present the set-up is further being improved towards first weak interaction measurements, while at the same time additional detection systems (including a tape station) are being built to further extend the measurements that can be performed with the intense, pure and scattering-free samples of exotic isotopes that can be prepared with WITCH.

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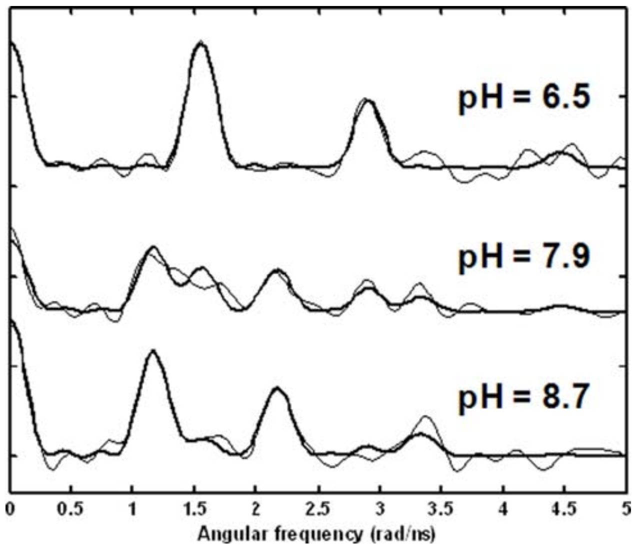
Nathal Severijns

IS448 - Pb(II) and Hg(II) binding to *de novo* designed proteins studied by ^{204m}Pb- and ^{199m}Hg-Perturbed Angular Correlation of γ-rays (PAC) spectroscopy: Clues to heavy metal toxicity

The biochemistry of the toxic heavy metal ions Pb(II) and Hg(II) is dominated by interactions with thiolates (R-S-) in both proteins and smaller biomolecules such as gluthathione [1,2]. Thus, the toxicity is believed to be related to the displacement of the native metal ion (typically Zn(II)) from functional or structural sites in proteins, leading to inactivation or incorrect function of these biomolecules. However, at the molecular level the cause and effect of heavy metal toxicity is still to a large extent unknown.



^{199m}Hg PAC signal from the de novo designed protein TRIL9C at different pH values. A structural change at the Hg(II) binding site is observed, see the text for details.

In this project we aim to elucidate the fundamental chemistry of heavy metal - protein interactions, and thus the mechanisms underlying heavy metal toxicity at the molecular level. We apply PAC spectroscopy in combination with more commonly used spectroscopic techniques in biochemistry (NMR, EXAFS, UV-Vis, and CD) as well as first principle (density functional (DFT) based) electronic structure calculations to interpret the spectroscopic properties in terms of molecular structure.

The systems we have investigated so far at ISOLDE (mainly in 2007) include:

(1) A variety of small model systems.
From the Cambridge Structural Database about 10 Hg(II) and 10 Pb(II) containing coordination compounds with biologically relevant ligands were selected. The PAC spectra for these constitute an empirical basis for interpretation of the data recorded for real biological systems, as well as test systems to validate the quality of the DFT calculations of electric field gradients. The ^{204m}Pb PAC experiments in 2007 gave the first ^{204m}Pb PAC data for a real coordination compound (i.e. with a molecular entity in the unit cell as opposed to previous ^{204m}Pb PAC data recorded for structures with polymeric crystalline character). Preliminary DFT calculations for this compound give (surprisingly) good agreement with the experimental data.

(2) De novo synthesized proteins.
As the name indicates these proteins are synthesized from scratch allowing for systematic investigations of the factors that govern heavy metal binding. In a case study on a synthetic protein (TRIL9C) we have demonstrated that ^{199m}Hg PAC and ^{199}Hg NMR spectroscopy provide complementary data [1] that allow us to monitor both structure and dynamics of the heavy metal binding site [3]. The PAC data for L9C at three different pH values are shown in the figure. The spectral changes indicate a transition from a linear [HgS2] complex (pH 6.5) over a mixture (pH 7.9) to a trigonal [HgS3]- complex (pH 8.7). The structural interpretation relies on similarity of the spectra with those recorded for coordination compounds. Thus, pH is a regulatory switch for the metal site structure, and this might also be the case for the bacterial Hg(II) biosensor MerR which has a [HgS3]- coordination geometry. Several other de novo designed were investigated, but the results are not described further here.

(3) Naturally occurring proteins.
The so-called HAH1 protein which functions as a copper transporter has been studied in solution at different pH values using ^{199m}Hg PAC. At low pH the signal appears to reflect a [HgS2] structure, in agreement with the known structure of HAH1 [4]. At high pH a new signal appears probably reflecting coordination of 1-2 thiolates from another HAH1 molecule, i.e. metal ion induced formation of a protein dimer, that may well reflect the process of transfer of the metal ion from one protein to another. Attemps to acquire information on the HIV peptide Ncp7 using ^{204m}Pb PAC spectroscopy have provided hints that the Pb(II) occupies a [PbS3]-binding site, but the signal-to-noise of the PAC spectra was not adequate to draw reliable conclusions.

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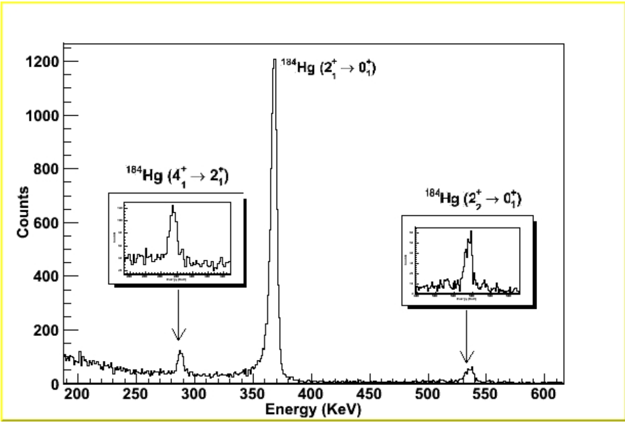
Lars Hemmingsen

IS452 - Coulomb Excitation of Low-Lying States of ^{184,186,188}Hg

Since isotope shift measurements [1] first observed a sharp shape transition in the ground states of light odd mass mercury isotopes, shape coexistence has been an actively studied phenomenon by means of in-beam spectroscopy. In light even mass mercury isotopes a weakly deformed oblate ground state band ($\beta_2 \approx -0.15$) is found to coexist with a more deformed ($\beta_2 \approx 0.25$)

prolate band. The prolate states are associated with the excitation of four protons across the Z=82 shell gap into the h9/2 and f7/2 (π(4p-6h) configuration) while oblate states are associated with the π(0p-2h) configuration [2,3]. There now exists a large body of evidence supporting the coexistence of different shapes at low excitation energies in mercury isotopes.



Doppler corrected spectra of ^{184}Hg showing de-excitation from first and second 2^+ states and the first 4^+ state after Coulomb excitation

In the summer of 2007 beams of ^{184,186,188}Hg were provided by ISOLDE and post accelerated by REX, for the first time, to an energy of 2.85 MeV/u and delivered to the MINIBALL detector array, making ^{188}Hg the heaviest post accelerated radioactive ion beam to date using the ISOL process. The isotopes of interest were produced with 1.4 GeV protons from the PS booster impinging upon a molten lead target. The nuclei were charge bred in EBIS to charge states of 43+ (^{184,186}Hg) and 44+ (^{188}Hg). The isotopes produced by this process passed through REX with an efficiency of 0.19%, though we are confident that future experiments will achieve a greater efficiency.

Post accelerated beams of Hg isotopes were delivered to ^{120}Sn and ^{107}Ag targets at intensities of 3000 pps (^{184}Hg) and 10^5 pps (^{186,188}Hg). These intensities were more than adequate for the observation of low lying Coulomb excited states associated with all three isotopes. The in-flight emitted γ-rays were observed in the highly segmented, high resolution MINIBALL detector array. The figure shows the Doppler corrected spectra for ^{188}Hg using a ^{120}Sn target. The high yields, together with known lifetimes [4-6] will allow the extraction of matrix elements for each transition, and will enable the magnitude and sign of the 2^+ diagonal matrix element to be determined, giving an accurate measure of deformation and mixing. Analysis is in progress to measure the E2 matrix elements for the lower states in these nuclei. The evolution of band mixing and deformation throughout the ^{184,186,188}Hg isotope chain will be investigated to enhance our understanding about the shape coexistence phenomenon in this part of the nuclear landscape.

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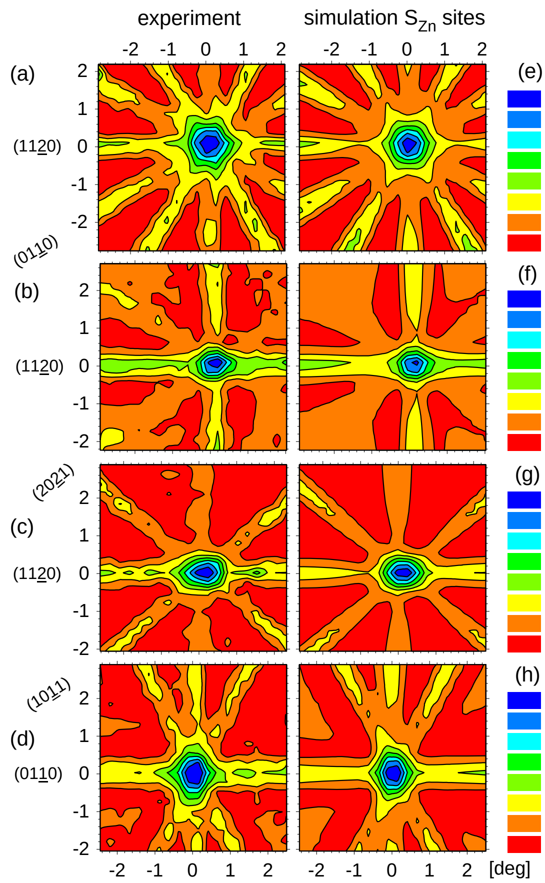
Andrew Petts and Nick Bree

IS453 - First results from electron emission channeling on-line experiments

Emission channeling with position-sensitive detectors is a well-established technique at ISOLDE for studying the lattice location of radioactive impurities implanted into single crystals. In the case of electron emitting isotopes, however, due to count rate limitations of the detection systems, the technique had been restricted to isotopes with half lives above ~6 h. Recently, major technical developments have been realized and new equipment has been acquired which has allowed these limitations to be overcome and made feasible electron emission channeling experiments with short-lived isotopes.



Panels (a-d) show the experimental β^- emission patterns from ^{61}Co in ZnO, in comparison to the theoretical patterns expected for ~60% of ^{61}Co on substitutional Zn sites panels (e-h). Note that the experimental patterns have not yet been corrected for the contribution of electrons backscattered from the sample, therefore 60% represents a lower limit for the substitutional CoZn fraction.

We report here on the results from the first electron emission channeling on-line run of the ECSLI ("Emission Channeling with Short-Lived Isotopes") collaboration, which took place during the June 2007 Mn beam. Using our new on-line setup which is equipped with a position-sensitive Si pad detector with fast readout system and which was mounted on the LA2 beam line, two isotopes were successfully used for β^- emission channeling experiments for the first time: ^{56}Mn (2.58 h) and ^{61}Co. While ^{56}Mn was available directly, ^{61}Co was obtained by means of implanting the short-lived precursor isotope ^{61}Mn and exploiting the decay chain ^{61}Mn (4.6 s) $\rightarrow$ ^{61}Fe (6 min) $\rightarrow$ ^{61}Co (1.6 h). The new detector readout system was found to reach data taking rates up to 3 kHz, thus allowing to use sample activities in the range 3-4 MBq without dead time losses, an essential feature for efficient measurements using short-lived isotopes. We are confident that by means of optimizing the detector readout hard- and software, taking into account the experience gained at the previous run, the maximum count rate can be increased even further.

During our run we were able to determine the lattice location of Mn in GaN and of Co in ZnO (see figure) in the as-implanted state and following annealing up to 900°C. In both cases it was found that the transition metals preferred substitutional cation (i.e. Ga or Zn) sites. Both Mn-doped GaN and Co-doped ZnO are semiconductor systems for which room temperature ferromagnetism has been reported and where lattice location experiments of the transition metals are of high interest [1].

Since the new on-line setup allows implanting the radiosotope and measuring the electron emission channeling patterns at the same time, there exists in principle no lower limit for suitable half lives as long as the radioactive beam intensity is high enough. Practical limitations, however, are due to the general trend that short-lived isotopes emit high-energetic beta particles which suffer significant straggling in the Si detector and can thus only be detected with worse position resolution, while at the same time the angular width of channeling effects decreases with particle energy. With the existing detectors, beta endpoint energies around 3-4 MeV are certainly feasible. In the future, besides ^{56}Mn and ^{61}Co we also intend to carry out lattice location experiments using ^{65}Ni (2.5 h) and ^{27}Mg (9.46 min). Since in all these cases no suitable long-lived isotopes for emission channeling exist, a range of new elements has been made available for lattice location experiments.

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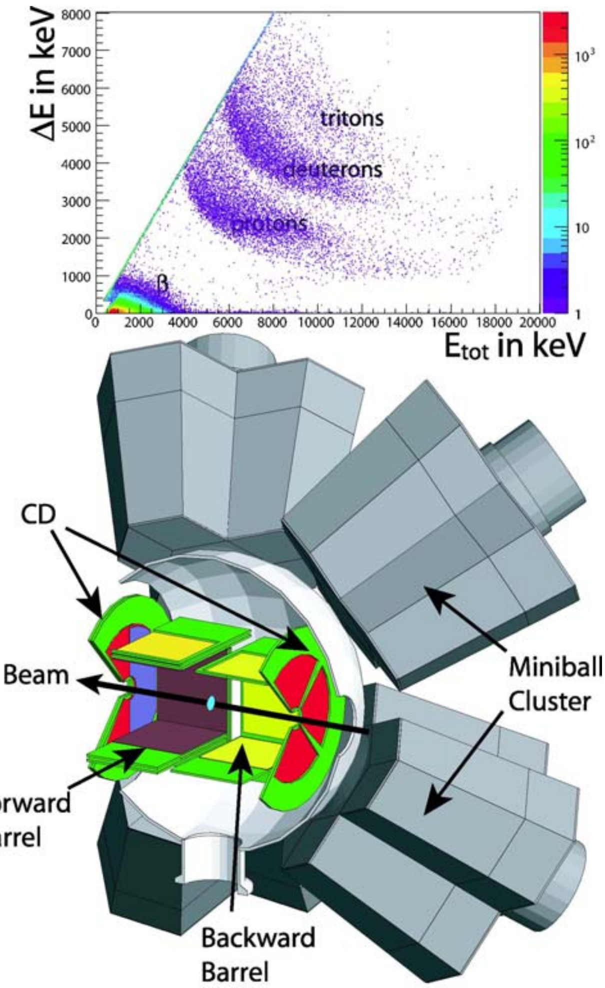
U. Wahl et al.

IS454

Light-ion induced transfer reactions are a well-established tool to study the single-particle structure of nuclei. From the energies of the ejectiles one can deduce the energies of single-particle levels and their angular distributions allow to determine the transferred orbital angular momentum. The relative spectroscopic factors extracted from the cross sections can give direct information on the occupation of single-particle levels. The results enable sensitive comparisons with theoretical model predictions.

At REX-ISOLDE, a major upgrade in instrumentation has been installed recently aiming to study transfer reactions with radioactive nuclei in inverse kinematics. A new array of silicon detectors has been designed and built [1] which fits inside the MINIBALL γ-spectrometer, as shown in the figure. It provides a large solid angle for particle detection (62% coverage of 4π) and a typical θ-resolution of about 5 degree.



New array of silicon detectors to study tranfer reactions with MINIBALL (bottom) and ΔE versus E_{tot} plot for a forward barrel quadrant (top.)

In backward direction, four quadratic position sensitive silicon strip detectors form a barrel (105-150 degrees) whose end cap (150-172 degree) is covered by an annular double-sided segmented silicon detector, a so-called CD detector. All detectors have a thickness of 500 μm. The barrel detectors in forward direction (30-75 degree) are implemented as a stack of a 140 μm thick position sensitive silicon strip detector and a 1000 μm thick silicon pad detector acting as a ΔE - E_{rest} telescope for particle identification. In the fully equipped array another CD detector, also implemented as telescope, will cover the very forward range (8-30 degree).

The new setup also comprises two new devices for an improved beam diagnostics. An active collimator consisting of four pin-diodes surrounding a 10 mm aperture has been placed at the entrance of the scattering chamber. In order to check the focus directly at the target position, a nine-fold segmented, 10 μm thin diamond detector (3x3 mm^2 pixel size) sitting on the target ladder can be moved into the beam.

In October 2007, the new setup has been used successfully for the first time in the IS454 experiment aiming to study the single-particle structure of ^{31}Mg by the d(^{30}Mg,^{31}Mg)p reaction at 2.85 MeV/u. The top of the figure shows a ΔE versus E_{tot} plot for a forward barrel quadrant. One can clearly distinguish the protons, deuterons and tritons from the different reactions. In the bottom left corner a strong background of electrons from β decay can be seen.

As an upgrade planned for 2008, the silicon detectors in the backward hemisphere will be backed with β detectors enabling a separation of electrons from low-energy protons in future experiments. Transfer reactions performed with the described new silicon array will become an important part of the research program at REX-ISOLDE. A first proposal to investigate also a two-neutron transfer reaction utilizing a tritium target has been approved recently. Although already now many interesting experiments can be performed, the energy upgrade in the frame of the HIE-ISOLDE project will allow to extend such studies towards heavier nuclei.

[1] V. Bildstein, et al., Progress in Particle and Nuclear Physics (2007), doi:10.1016/j.ppnp.2007.01.010

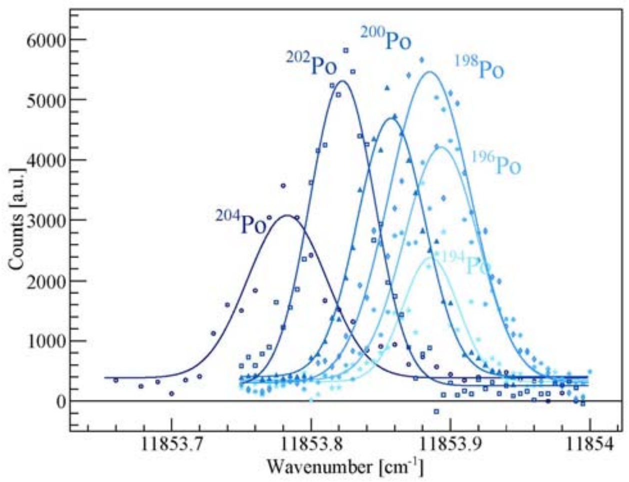
Vinzenz Bildstein

IS456 - Into the shape of the polonium isotopes

The Resonant Ionisation Laser Ion Source (RILIS) at ISOLDE is a driving force, for already several years, by providing beams always more pure and more exotic [1-2]. Recently, it has also been a fine measuring tool in the determination of the mean-squared charge radii (mscr) and nuclear moments of ground- and isomer-states in high-Z nuclei like lead (Z=82) [3-4] and bismuth (Z=83) [5]. The study of the mscr along an isotopic chain gives a direct observation of the deformation [3]. The moments allow for precise spin assignment and the evaluation of quadrupole deformation for odd-A isotopes [2].

The collaboration who was involved in those measurements is now tackling the shape coexistence in the neutron-deficient polonium isotopes (Z=84). Several spectroscopic studies [6-9] have indeed highlighted this issue without ever being able to assert the precise shape of the nuclei.

Last August, ten isotopes ($^{193-200,202,204}$Po) and four isomers (^{193m,195m,197m,199m}Po) were studied, juggling between GLM (for the alpha-decaying isotopes) and the tape station (for the beta-gamma-decaying ones). The atoms, produced from the fission of the uranium target by the 1.4 GeV protons from the PS-Booster, were ionised with a new scheme from the RILIS [10]. They were then separated by the GPS analysing magnet and implanted in different decay chambers, respective of their different decay modes. The frequency of one of the mutiple steps required to complete the ionisation scheme was scanned across its resonance. The observation of the activity with respect to the scanned frequency yields thus the optical spectrum of interest. The spectrum of each even-mass isotope is shown on the figure.



Optical spectra of the even-mass polonium isotopes ^{194,196,198,200,202,204}Po. The units on the y-axis are arbitrary since each curve had to be rescaled separately for better display. ^{194,196,198}Po were measured through alpha decay; ^{202}Po was measured through its emitted beta particles; ^{200,204}Po were measured from gamma radiations following their respective beta decay.

From ^{204}Po to ^{198}Po, one observes a fairly regular separation between the resonance curves. On the other hand for ^{194,196,198}Po, the dynamic totally changes and these three isotopes show no isotopic shift. This would mean that, when going from heavy to light mass, the expected deformation effects appear much earlier than the spectroscopic studies concluded.

Moreover, the study of the more complicated hyperfine structure of the ground- and isomer-states of the odd-A isotopes hints at more unexpected results like large quadrupole deformation or different spin assignments, again challenging conclusions from the spectroscopic studies.

Finally, new spectroscopic information has been found thanks to the identification of the hyperfine structure of some previously unknown transition: the cross-over alpha decay from ^{195m}Po ($I=13/2^+$) to ^{191}Pb ($I=3/2^-$) can now be determined and the relative feeding of the beta decay of ^{199}Po ($I=3/2^-$) and ^{199m}Po ($I=13/2^+$) to gamma transitions in ^{199}Bi can also be determined more accurately than previous studies [11].

[1] V.N. Fedosseev et al., Hyperfine Interact. 127 (2000) 409
[2] U. Köster et al., Nucl. Instr. and Meth. B 204 (2003) 347
[3] H. De Witte et al., Phys. Rev. Lett. 98 (2007) 112502
[4] M. Seliverstov et al., to be published
[5] B.A. Marsh et al., Ph.D. thesis (2007)
[6] N. Bijnens et al., Phys. Rev. Lett. 75 (1995) 4571
[7] A.N. Andreyev et al., Phys. Rev. Lett. 82 (1999) 1819
[8] P. Van Duppen et al., Hyperfine Interact. 129 (2000) 149
[9] R. Julin et al., J. Phys. G 27 (2001) R109
[10] T.E. Cocolios et al., submitted to Nucl. Instr. and Meth. B (EMIS2007 proceedings)
[11] R.E. Stone et al., Phys. Rev. C 31 (1985) 582

T.E. Cocolios

How to obtain access to the ISOLDE hall

1. Register at the CERN Users office[2]. You need to bring
   a. Registration form **signed by team leader or deputy[3]** of your experiment
   b. Proof of attachment to Institute or University **in English or French**
   c. Passport
   d. Copy of medical insurance (for illness and accidents)
   e. List of contacts in case of emergencies.
2. Get your CERN access card in Building 55

With this registration procedure you become a **CERN user[4]**.

3. Follow the CERN basic safety course (levels 1 to 3) consisting of a 50 minute video. It is shown in Building 55 Monday to Friday at 9:00 and 10:00 (in French) and 14:00 and 15:00 (in English)[5].
4. Follow the radiation protection course if you need to get a permanent personal dosimeter[6]. Please make a reservation for the course via EDH (CERN Electronic Document Handling) well in advance of your arrival at CERN[7].
5. Obtain a radiation dosimeter at the Dosimetry service, located in Building 55[8]. Two options exist:
   a. Temporary dosimeter. Issued only once per calendar year for a maximum of 2 months.
   b. Permanent dosimeter. A medical certificate[9], valid for 24 months, is required. The permanent dosimeter needs to be readout monthly[10].
6. Follow the special web-based safety course for the access to ISOLDE[11].
7. Apply for access to ISOLDE hall using EDH: https://edh.cern.ch/Document/ACRQ. This can be done by any member of your collaboration (typically the contact person) having an EDH computing account[12].

Find more details at the information about registration for Users page.

New users are also requested to visit the ISOLDE secretariat while at CERN.
Opening hours:
Mon., Tues., Thurs., Fri. 08:30-12:30
Mon. & Thurs. 13:30-15:30

Alexander Herlert

[2] http://ph-dep.web.cern.ch/ph-dep/UsersOffice/ (Building 61, open 8:30-12:30 and 14:00-16:00, closed Wednesday morning).
[3] Make sure that the registration form is signed by your team leader before coming to CERN or that it can be signed by the team leader or deputy upon arrival.
[4] The first registration as USER needs to be done personally, so please note the opening hours. In case of need the extension of the registration can be delegated or performed on-line via EDH.
[5] At present, no access to the ISOLDE hall is granted without the safety course.
[6] The radiation protection course is mandatory to obtain a permanent personal dosimeter.
[7] If it is not possible to sign up for a course, a temporary dosimeter can be issued for the first registration at CERN.
[8] http://cern.ch/service-rp-dosimetry (open *only in the mornings* 08:30 - 12:00).
[9] The medical certificate must be brought in person to the Dosimetry Service (either by the user or by his/her representative)
[10] There are reader stations at the ISOLDE hall and the CERN main building. You can leave your *permanent dosimeter* at the panel outside the ISOLDE secretariat.
[11] The new ISOLDE web course will be available in Summer this year and will be mandatory to obtain access to the ISOLDE hall.
[12] Eventually you can contact the secretary or the Physics coordinator.

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